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Energy efficiency in housing —

Part 1: Code of practice for energy efficient refurbishment of housing

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Committees responsible for this British Standard

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Association for the Conservation of Energy
Association of Building Component Manufacturers Ltd.
Association of County Councils
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Autoclaved Aerated Concrete Products Association
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Foreword

BS 8207 sets out the basic principles to follow in the pursuit of energy efficient, economical buildings. This Part of BS 8211, which has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Committee, shows how the principles of BS 8207 may be applied to the renovation of housing.

This standard does not attempt to lay down absolute criteria for comfort, services, performance and efficiency as these have to be decided according to the circumstances of each application, it does set out the factors which influence these criteria, and methods for making energy efficient decisions.

Energy use in housing depends on a number of factors. These include the location of the building, its specification, its heating system and other energy using services, the climate, and the way in which the dwelling is used (including patterns of space and water heating and the use of lighting and appliances).

Because of the close relationship of this subject with the provision of ventilation and the control of humidity and condensation in housing, this Part of BS 8211 should be read in conjunction with BS 5250, BS 5720 and BS 5925.

It is also important to avoid risks of rain penetration through walls, and this Part of BS 8211 should be read in conjunction with BS 5618, BS 6232-1 and BS 6232-2, BS 6676-1 and BS 6676-2 and BS 8208-1 and BS 8208-2, where appropriate.

Many energy efficiency measures are simply improvements or extensions to existing practice, while others are novel in one way or another. Whatever their origin, proposed energy efficiency measures should be evaluated in terms of their buildability, durability and their possible side effects on ventilation and condensation.

A calculation method, suitable for estimating energy use and costs, is included as Appendix A. It is based on BREDEM [1)] a model developed from extensive research in occupied housing by the Building Research Establishment. Development of the model is continuing and it will be updated periodically.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[1)] *The BRE Domestic Energy Model Background, philosophy and description.* BRE Report BR 66, 1985. Anderson B.R., Baldwin R., Clark A.J., Milbank N.O.

Section 1. General

1 Scope

This Part of BS 8211 gives guidance for achieving energy efficient design in the renovation or improvement of existing housing.

The factors which influence energy use are listed together with procedures which enable the relationship between energy use, internal and external environment, and capital and running costs to be explored and evaluated.

A calculation method for estimating energy use and costs in housing is given in Appendix A, which can be used for evaluating designs.

A bibliography, containing some of the more important sources of information relevant to this topic, is given in Appendix B.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 8211, the definitions given in BS 3533 apply together with the following.

2.1
energy efficiency

economic use of energy having regard to capital, running and maintenance costs

2.2
energy efficient design

design that achieves optimal or near optimal energy efficiency

3 Factors affecting energy use

3.1 General

The factors listed in **3.2** to **3.6** under the headings of weather, user behaviour and requirements, building design, space heating system and services, all have a bearing on energy use, internal environmental conditions, and the standard of services.

It should be noted that comfortable living accommodation requires adequate internal air and surface temperatures, adequate air quality and freedom from problems of condensation, mould growth, pattern staining and draughts. Sufficient levels of ventilation and thermal insulation should be provided to meet these objectives.

The designer has, within the constraints of his brief and the existing building structure, control over the specification of the building and its integral services such as heating, domestic hot water and lighting. The designer, however, has to proceed on the basis of given weather data and assumptions concerning user requirements and appliance use. By contrast the occupier has control over the use of the services but limited scope to alter the design.

The designer should bear in mind that some aspects of the building design, such as integration of insulation with the structure, should where possible reflect its anticipated lifetime. On the other hand the heating system (or components of it) could be replaced after 10 years to 20 years, whilst the user requirements may change over a much shorter timescale.

Many of the factors listed in **3.2** to **3.6** are interrelated; for example, ventilation rates depend on the building itself (leakage cracks and ventilation openings), on the weather (wind velocity), and on the user (opening of windows). Similarly, a change in one variable may affect another; for example, a change in heating period may affect the usefulness of the solar gains.

3.2 Weather

The following factors vary with locality, exposure, building height and the local microclimate:

a) external temperature which affects fabric and ventilation losses;

b) solar radiation which affects solar gain;

c) wind which affects ventilation losses and surface resistances;

d) rain which can affect thermal conductivities and subsequent evaporation can reduce outside surface temperatures.

3.3 User behaviour and requirements

The following factors affect internal temperature levels, internal heat gains and heat losses:

a) occupancy, i.e. the number of people in the household and the proportion of time that they normally occupy the premises, their activity levels, age and physical condition;

b) space heating, i.e. temperature levels, the duration of periods of heat demand, the proportion of the dwelling that is heated;

c) water heating requirements;

d) the use of space and water heating controls;

e) cooking requirements;

f) lighting requirements;

g) the use of appliances;

h) window opening and the use of ventilation systems;

i) acceptable running costs.

3.4 Building design

The following factors are relevant in building design:

a) position on the site and orientation;

b) area of external envelope;

c) *U*-values of (and thermal bridges in) the various parts of the external envelope which together with the areas of each part determine the fabric losses;

d) ventilation openings and air leakage paths, and provision for ventilation control which together with wind speed and window opening determine the ventilation losses;

e) glass areas and solar transmission characteristics, shading, orientation and also curtains (and the extent to which they are used), which affect glazing *U*-values and the solar gain;

f) internal heat transfer, by transmission through internal partitions and by air movement between rooms, affected by room layout and internal door opening habits. This factor is most significant when part of the dwelling is unheated;

g) thermal capacity of materials, particularly those at the interior surfaces of external walls. This affects the rate of heating and cooling of the structure at the beginning and end of heating periods, the plant margin required for intermittent operation of the heating system, and also the usefulness of internal and solar gains. Furnishings also have an influence on thermal mass. Thermal mass can be utilized in passive solar designs (in conjunction with shading and ventilation) to avoid summer overheating;

h) the areas and construction of party walls and floors in calculations where it is assumed that adjacent dwellings may be at a different temperature level from the one under consideration, e.g. in the sizing of heating systems.

3.5 Space heating system

The following factors are relevant to space heating systems:

a) the efficiency of the heating system, i.e. the ratio of the heat released into the dwelling to the calorific content of the fuel delivered to the premises. This takes account of heat regain from flues, effects of running at less than maximum output, intermittent operation, and additional losses associated with including the heating elements within the building fabric, e.g. underfloor or ceiling heating;

b) the provision of sufficient ventilation for conventionally flued appliances which will affect the ventilation heat losses;

c) the responsiveness of the heating system, i.e. the system's ability to respond to changes in heat demand. Responsiveness affects temperature levels during unheated periods, and also the utilization of internal and solar gains, and consequently affects the energy consumption;

d) proper sizing of the system as oversizing will usually involve a capital cost penalty, and in some cases a higher running cost if the appliance efficiency is reduced whilst undersizing will result in the required conditions not being achieved in cold weather. For systems designed for intermittent operation, some oversizing is needed for warm-up periods;

e) the heating system controls, i.e. time switches, thermostats, zone control;

f) the choice between centralized or decentralized heating and hot water plant, between centralized or individual control, and between centralized or individual metering;

g) the cost and convenience of fuel and the method of payment for fuel;

h) the convenience and reliability of the heating system, i.e. ease of use, maintenance frequency and costs, and extent of user knowledge required.

3.6 Services

The following factors are relevant to services:

a) domestic hot water, i.e. the type of water heating system, the controls, the fuel used, the storage and distribution system, and the insulation of tanks and pipework;

b) cooking, i.e. the type of cooking equipment and fuel;

c) lighting, i.e. the number of lamps in use and their luminous efficiency;

d) appliances, i.e. the number of appliances in use and their efficiency.

4 Energy efficiency

Energy efficiency implies the economic use of resources, and often it is appropriate to subject the energy and maintenance costs and the capital investment costs to a suitable economic analysis. Energy efficiency should form part of an integrated approach to housing costs.

Cost, which theoretically integrates all economic factors, is an essential though imperfect tool for the evaluation of energy efficiency. Many energy efficiency measures may be achieved with little or no extra cost if considered as an integral part of the design. Others have benefits such as improved amenity or improved comfort. Energy efficiency can also improve the marketability of the property.

Calculations usually have to be based on estimates of capital costs, maintenance costs and future energy prices, which are all subject to change, together with less tangible factors such as improved amenity.

The economic objective is normally:

a) to achieve a required rate of return on investment; or

b) to obtain the best return for a fixed budget; or

c) to achieve a stated standard of performance at least cost; or

d) to meet some other economically measurable criterion.

The basis of assessment should be determined in conjunction with the client or occupant (see clause **6**).

NOTE Types of economic analysis are described in BS 8207.

Different cost criteria and constraints may apply in the improvement of existing properties depending on whether energy efficiency measures are incorporated with other renovation work. Energy efficiency could feature in discussions about refurbishment as an alternative to demolition.

Section 2. Design and construction approach

5 Methodology

The methodology involves establishing certain parameters or constraints, making an initial design, testing it against the requirements of the brief, and adjusting the design as necessary (see Figure 1).

6 Preparation of brief

A brief, agreed with the client, should include the following:

a) anticipated use and occupancy of the dwelling;

b) design opportunities and constraints, i.e. fuel availability, local planning permission, limitations imposed by the existing structure, special factors as might be imposed due to listed buildings or conservation areas;

c) required space heating and comfort standards at specified outside conditions including background heating levels;

d) requirements for other energy services, i.e. domestic hot water, cooking, lighting, etc.;

e) energy performance targets (see clause **8**);

f) calculation procedures to be used for estimating environmental and energy performance (see clause **9**);

g) capital and running cost constraints;

h) economic criteria and priorities, i.e. acceptable payback, required rate of return, etc.

For many projects the client is not the eventual occupier. In such cases the designer and client should take steps to endeavour that the brief reflects the real needs and expected behaviour of prospective (or probable) occupants.

The site and building should be surveyed, any existing problems noted and suitable requirements incorporated in the brief. In some cases a detailed prior examination of the property may be appropriate, e.g. infra-red thermographic surveys, pressure testing of air infiltration.

7 Design evaluation

As the design is evolved it should be checked against the brief. In particular, energy performance should meet the recommendations of items c) and d) in clause **6** and the energy target of item e) in clause **6**. If these recommendations cannot be met then further design improvements should be considered and the complete design re-evaluated. Factors affecting energy use are discussed in clause **3**.

During the evaluation of the design and the design options the designer should give full consideration to both energy and non-energy benefits of improvements (for example, improved appearance or amenity, better comfort levels).

Thermal bridges and significant variations in insulation level at different parts of the fabric can give rise to low internal surface temperatures at these places, with the attendant risk of surface condensation, pattern staining, mould growth and downdraughts. Thermal bridges, therefore, need special attention in many existing buildings. A good design will avoid thermal bridges and provide relatively uniform standards of insulation over the whole fabric (see BS 5250).

Provision should be made for acceptable minimum air change rates (see BS 5250 and BS 5720) and consideration given to means for removing moisture at source, such as the provision of extractor fans in moisture producing areas.

Vapour control layers should be included where needed to avoid interstitial condensation (see BS 5250 for methods of assessment of condensation risk and recommended design detail).

It is essential that the roof space above insulated ceilings is adequately ventilated (see BS 5250) and well-insulated ceilings may require special attention to insulation of pipework and cisterns in the roof space (see BS 5803-1 to BS 5803-5).

Care should be taken to ensure that insulation materials are suitably chosen (see BS 5422). When cavity-fill insulation is involved, it is essential to take precautions to avoid the risk of rain penetration, both in the specification of the insulation materials (taking account of the exposure of the building concerned) and in the installation of the materials (see BS 5617, BS 5618, BS 6232-1 and BS 6232-2, BS 6676-1 and BS 6676-2 and BS 8208-1 and BS 8208-2).

The possibility of overheating in summer should also be considered.

NOTE Guidance on various aspects of design and practice is given in BRE Digests and Defect Action Sheets (see Appendix B).

It may prove difficult to meet the energy performance requirements within the cost and economic criteria given in the brief. In such cases the client should be consulted and an appropriate relaxation of the criteria in the brief should be agreed.

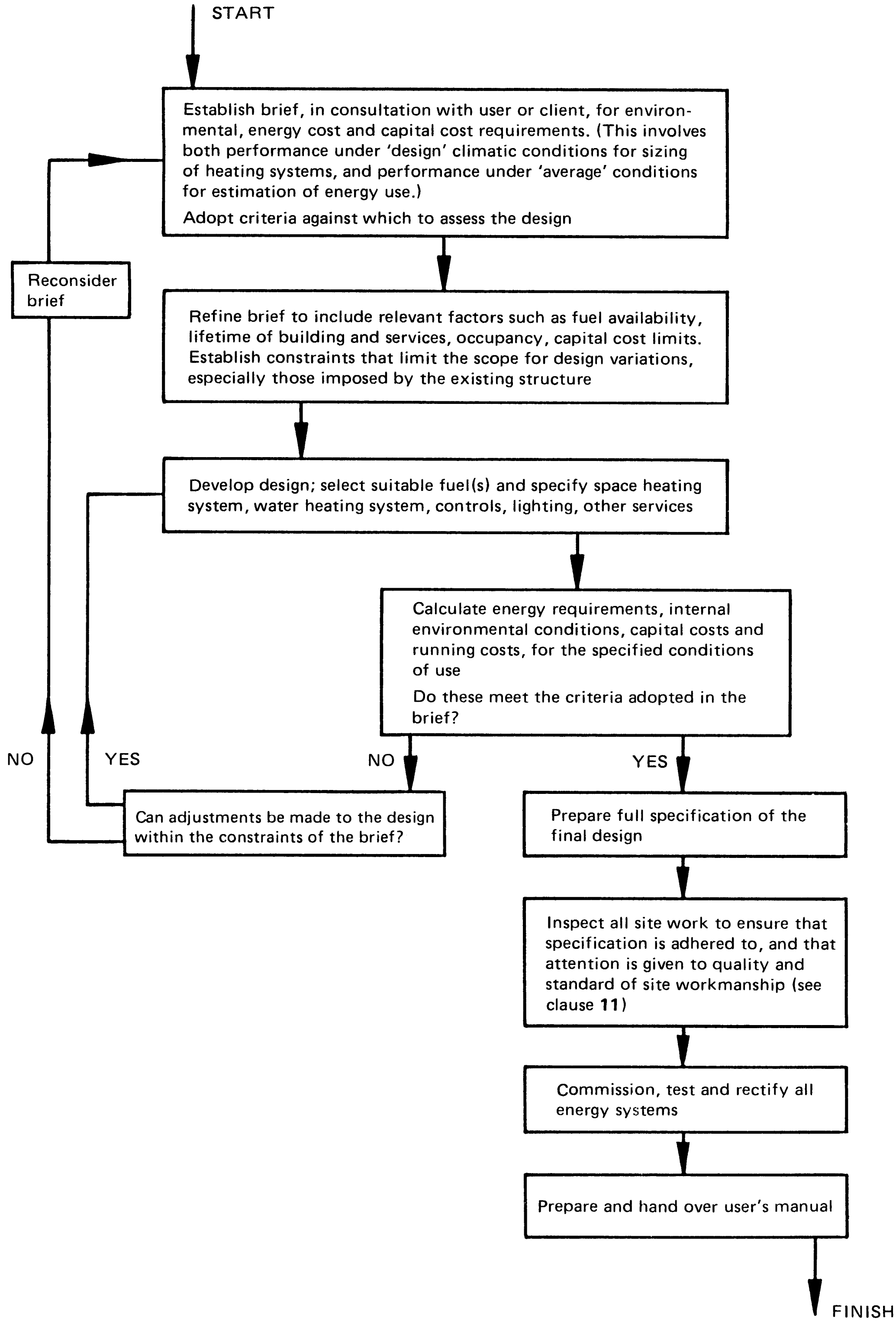

Figure 1 — Flow chart

8 Energy performance targets or indicators

Energy performance targets or indicators can take many forms. The appropriate type and level of target should be selected in consultation with the client when drawing up the brief.

Performance of designs can be judged by the following:

a) minimum specifications (for fabric elements, heating systems, etc.);

b) maximum *U*-values for individual fabric elements or assemblies;

c) global insulation or heat loss factors;

d) maximum energy use or cost for specified operating conditions;

e) an energy label or index;

f) minimum rate of return, maximum payback, or other economic criteria.

9 Calculation method for energy use

A calculation method is needed when a more complex type of performance indicator is being used, e.g. as in items d), e) or f) of clause **8**. Any calculation method adopted for energy use should take account of the factors listed in clause **3**. It also needs to be suited to the resources of the designer.

A calculation method adopted for showing compliance with targets can only be used when those targets have been derived using the same calculation procedure.

Appendix A provides a method that can readily be implemented on a small computer and which is suitable for most design situations.

Actual energy use can differ from that predicted due to simplifications in the calculation procedure and to differences between the assumed and actual conditions and patterns of use.

10 Site supervision

Adequate site supervision is essential to ensure that the specification is adhered to and to avoid unnecessary problems which may not become apparent until after the property is occupied. It is essential that the designer takes account of what effect any departure from normal building practices will have on the craftsman. Site staff, particularly supervising staff, may need special training so as to appreciate the importance of adhering to the specification. Departures from the specification will often be concealed a very short time after they have been made. It is essential that in all aspects of building work every person involved understands the objectives of the design and specification and how they are to be realized.

Particular attention should be paid to the following:

a) installation of vapour control layers in walls and ceilings. It is essential that these are free from holes and tears, that they are correctly positioned, i.e. on the warm side of the insulation, and that adjoining sections overlap. Unavoidable perforations for services should be kept small and sealed with an airtight seal;

b) continuity of damp proof membranes;

c) installation of insulation to avoid gaps. Ceiling insulation should be closely fitting and carried into the eaves to meet the wall insulation while still permitting ventilation of the roof void. To avoid thermal bridges around windows and doors, it is essential that internal insulation of walls be returned into the reveals;

d) draughtsealing to doors and windows should be checked for proper operation;

e) sealing round pipes and cables which penetrate the fabric. This is very important in ceilings, and also where services enter the building for example, via an external meter cupboard;

f) protection of materials (see Good Practice Notes. Practice Note 1. *Cavity insulated walls*[2]). Precautions should be taken where appropriate to prevent materials becoming wet or damaged before installation. After installation precautions should be taken to protect insulants from damage and external sources of water;

g) precautions should be taken to avoid hazards in relation to electrical installations, e.g. electric cables which need to be de-rated appropriately if covered by thermal insulation;

h) precautions are needed to prevent freezing of pipes and tanks in unheated spaces such as lofts.

[2] Available from several outlets (see publications referred to).

11 Testing and commissioning

All energy systems and controls should be properly commissioned and set for correct operation. A record of the tests carried out and their results should be provided for the occupier or given to the client. Further adjustments as necessary should be made after occupancy.

For large projects or projects involving unusual or complicated energy efficiency measures additional test procedures, such as infra-red thermographic surveys of insulation or pressure testing of air infiltration, may be justified.

12 Information for owners and householders

The owner and/or householder should be provided with a user manual containing the following information:

a) a description of the property and the energy efficiency measures included in its design;

b) the location of equipment, tanks, valves, circuit breakers, controls etc., routes of pipes and cables;

c) maintenance instructions for all energy using equipment, special efficiency measures, etc. Information on how frequently equipment needs to be serviced and indication of what equipment can be maintained by the user together with suitable instructions;

d) instructions for the operation and control of all energy equipment and services, e.g. central heating, with suggested modes of operation to meet particular user requirements. If the design includes any special features their purpose and mode of operation should be explained in detail;

e) advice on the energy efficient use of the property, e.g. avoiding excessive ventilation, closing curtains at night;

f) advice on prevention of condensation;

g) a log book for monitoring energy use, e.g. by periodic meter readings;

h) a log book for recording modifications to the property and its services, maintenance, etc;

i) a user feedback questionnaire;

j) any testing and commissioning certificates;

k) the names and addresses of organizations, such as fuel boards, from which the householder can seek advice on servicing, operation and running costs.

Section 3. Efficiency in use

13 Maintenance

Proper servicing and maintenance of heating and other appliances is essential if the optimum energy efficiency of a home is to be maintained. Regular servicing is also necessary for the safety of some appliances.

14 Monitoring

The occupier should be encouraged to monitor energy use for the following reasons:

a) so as to be aware of fuel expenditure;

b) to identify any shortfall in performance;

c) to observe the effect of major changes in lifestyle and the effect of the use of appliances.

Simple actions such as periodic meter readings can provide valuable indications.

15 Modification

Most buildings are designed for a long lifetime and measures incorporated in the original design may become inadequate. When a suitable opportunity occurs, such as a change in ownership, any energy performance indicator should be compared with current practice. When appropriate, an audit should be carried out (the calculation method in Appendix A provides a suitable basis), the options examined, and worthwhile measures carried out. The effect should then be monitored (see clause **14**).

Appendix A Energy use calculation

A.1 General

The following calculation method is recommended for estimating energy use and costs.

NOTE Data on the house and the results of calculations are entered into the boxes thus: [ ] . The boxes are numbered sequentially and some of the results are needed in later calculations. Where this occurs the transfer is indicated by a shaded box thus: [shaded box]

A.2 Overall house dimensions

Enter the dimensions, areas and volumes in metric units (metres and square metres, etc.).

Enter the dimensions, areas and volumes in metric units (metres and square metres, etc.).

Ground floor area	[ ]	(1)	Average storey height	[ ]	(6)
First floor area	[ ]	(2)			
Second floor area	[ ]	(3)	House volume (5) × (6)	[ ]	(7)
Third floor area	[ ]	(4)			
(continue as necessary)	[ ]				
Total floor area (1) + (2) + (3) + (4) + . . .	[ ]	(5)			

A.3 Ventilation rate

Enter the air change rate in box (8). Take professional advice as appropriate in the absence of specific information for the house under consideration. If mechanical ventilation with heat recovery is installed, the air change rate used in the energy calculation should be reduced to allow for the heat recovered.

Total air change rate per hour [ ] (8)

A.4 Calculation of heat loss

Enter only the areas of external elements (do not include party walls or internal floors). For the roof enter the plan area of the loft. Where rooms are built into the roof enter the sloped area as an "other" element. For walls calculate the gross external area, then subtract the areas of windows and doors to give the net wall area.

NOTE Methods of calculation of *U*-values are given in the CIBSE Guide Section A3 1980[3)].

Element		*U*-value (in W/(m^2·K))		Area *A* (in m^2)		*U* × *A* (in W/K)	
Windows (single glazed)		[ ]	×	[ ]	=	[ ]	(9)
Windows (double glazed)		[ ]	×	[ ]	=	[ ]	(10)
Doors		[ ]	×	[ ]	=	[ ]	(11)
Walls (net area)		[ ]	×	[ ]	=	[ ]	(12)
Ground floor		[ ]	×	[shaded] (1)	=	[ ]	(13)
Roof		[ ]	×	[ ]	=	[ ]	(14)
Other elements		[ ]	×	[ ]	=	[ ]	(15)
Ventilation	0.33 ×	[shaded] (8)	×	[shaded] (7)	=	[ ]	(16)
Total specific heat loss *L* (in W/K) = (9) + (10) + . . . + (15) + (16) =						[ ]	(17)

NOTE 0.33 is a factor which incorporates the specific heat capacity of air at constant pressure at 20 °C [1 006 J/(kg·K)], the density of air at 100 kPa and 20 °C (1.184 kg/m^3) and the conversion of air changes per hour to air changes per second (1/3 600), i.e. 1 006 × 1.184/3 600 = 0.33.

[3)] Available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

A.5 Heating system efficiency

Identify the heating system and obtain a value for its efficiency, taking professional advice as appropriate. Existing systems may have efficiencies lower than that of equivalent new systems, depending on their condition; inspection of the system is required in individual cases. For some appliances the efficiency depends on the load relative to the maximum rating.

Heating system efficiency (in %) [ ] (18)

A.6 Mean internal temperature

Obtain a value for the mean internal temperature (in °C) of the house over the heating season, taking professional advice as appropriate. The calculation of the mean internal temperature should take account of the following factors:

a) design internal temperatures;

b) heating periods;

c) background heating;

d) heating system output characteristics;

e) heating controls;

f) internal and solar heat gains;

g) external temperatures;

h) fabric and ventilation loss;

i) thermal capacity of the building materials.

Mean internal temperature (in °C) [ ] (19)

A.7 Internal gains

Obtain a value for internal heat gains (in W), taking professional advice as appropriate. The calculation of internal heat gains should take account of the following sources of heat gain:

a) metabolic (from occupants);

b) standing losses from hot water tanks and pipes, latent heat released from hot water system at point of use;

c) heat gains from the use of cooking appliances;

d) lighting and electrical appliances.

Internal gains (average value in W) [ ] (20)

A.8 Solar gains

Enter the total window area at each orientation (window areas to be entered are gross window areas, including the window frame).

	Area (in m^2)	Solar flux (in W/m^2) single or double glazed		Gains (in W)	
North facing windows	[ ]	× 9.9 or 8.4	=	[ ]	(21)
South facing windows	[ ]	× 30.7 or 25.9	=	[ ]	(22)
East or west facing windows	[ ]	× 18.1 or 15.2	=	[ ]	(23)
Solar gains (UK average)		(21) + (22) + (23)	=	[ ]	(24)

Obtain the regional factor from table 1.

Corrected regional gains (in W) = regional factor [ ] × [ ] (24) = [ ] (25)

Total gains G (in W) [ ] (20) + [ ] (25) = [ ] (26)

Gains/loss ratio (G/L) [ ] (26) ÷ [ ] (17) = [ ] (27)

Obtain the utilization factor from Table 2 using (27) for value of G/L

Gains (in W) = utilization factor [ ] × [ ] (26) = [ ] (28)

Table 1 — Regional factors for solar gains and degree-days

Region	Solar factor	Degree-day factor
South West	1.23	0.79
Southern	1.10	0.91
South East	1.08	0.98
Thames Valley	1.02	0.85
East Anglia	1.07	0.99
Severn Valley	1.16	0.89
Midlands	1.06	1.01
East Pennines	1.00	0.96
Wales	1.15	0.91
West Pennines	1.03	0.96
North East	1.02	1.01
Solway	0.97	1.02
Tweed	0.97	1.09
West Scotland	0.96	1.05
East Scotland	0.91	1.10
North East Scotland	0.98	1.16
Highland	0.85	1.16
Western Isles	0.90	1.12
Orkney	0.87	1.22
Shetland	0.84	1.28
Northern Ireland	1.03	1.02

Table 2 — Utilization factors for corresponding gains/loss ratio

Gains/loss ratio (*G*/*L*)	Utilization factor
1	1.00
2	1.00
3	1.00
4	0.99
5	0.97
6	0.95
7	0.92
8	0.89
9	0.86
10	0.83
11	0.81
12	0.78
13	0.75
14	0.72
15	0.70
16	0.68
17	0.65
18	0.63
19	0.61
20	0.59
21	0.58
22	0.56
23	0.54
24	0.53
25	0.51
30	0.45
35	0.40
40	0.36
45	0.33
50	0.30

A.9 Degree-days

Use the gains and the total specific heat loss to calculate the temperature rise due to the gains. Subtract this from the mean internal temperature to obtain the base temperature and obtain the corresponding degree-days from Table 3. Interpolate between entries if the temperature is not exactly matched in the table. Obtain the regional degree-day factor from Table 1 to adjust for different regions of the country.

Temperature rise from gains (in °C) (28) ÷ (17) = (29)

Base temperature (in °C) (19) − (29) = (30)

Degree-days [use the base temperature obtained in (30) in Table 3] (31)

Corrected degree-days = regional factor × (31) = (32)

Table 3 — Degree-days as a function of base temperature

Base temperature	Degree-days	Base temperature	Degree-days
°C		°C	
1.0	0	11.0	1 140
1.5	30	11.5	1 240
2.0	60	12.0	1 345
2.5	95	12.5	1 450
3.0	125	13.0	1 560
3.5	150	13.5	1 670
4.0	185	14.0	1 780
4.5	220	14.5	1 900
5.0	265	15.0	2 015
5.5	310	15.5	2 130
6.0	360	16.0	2 250
6.5	420	16.5	2 370
7.0	480	17.0	2 490
7.5	550	17.5	2 610
8.0	620	18.0	2 730
8.5	695	18.5	2 850
9.0	775	19.0	2 970
9.5	860	19.5	3 090
10.0	950	20.0	3 210
10.5	1 045	20.5	3 330

A.10 Space heating

First calculate the net space heating energy requirement, then obtain the fuel needed by dividing this by the efficiency of the heating system [box (18)]. The space heating requirement per square metre is a useful indicator of the performance of the fabric of the house.

Space heating energy requirement	0.0000864 ×		(32) ×		(17) =		(33) GJ
Space heating per square metre			(33) ÷		(5) =		(34) GJ/m^2
Space heating fuel required	100 ×		(33) ÷		(18) =		(35) GJ

NOTE 0.0000864 is the conversion factor for converting watt-days to gigajoules.

If heating by off-peak electricity is used, enter the fraction of the total space heating requirement provided by off-peak electricity in box (36) (the remainder being provided by full-rate electricity), taking professional advice as appropriate. This fraction depends on the total installed storage capacity and on the type of storage heaters.

						(36)
Space heating (off-peak)		(36) ×		(35) =		(37)
Space heating (full rate)		(35) −		(37) =		(38)

A.11 Auxiliary fuel use

Obtain values for the following fuel uses, allowing for the size of the dwelling and its occupancy, taking professional advice as appropriate:

a) electricity for lights and appliances;

b) fuel for cooking;

c) water heating consumption and water heating efficiency;

Enter these, expressed in G J/annum, in boxes (39), (40) and (41) respectively.

For boiler systems that provide both space and water heating, the water heating efficiency should take account of the reduced boiler load in summer.

Electricity used in lights and appliances				[ ]	(39)
Cooking fuel				[ ]	(40)
Water heating use (in GJ/annum)				[ ]	(41)
Water heating efficiency (in %)				[ ]	(42)
Water heating fuel	100 ×	(41) ÷	(42) =	[ ]	(43)

If water heating by off-peak electricity is used enter the fraction of the total water heating provided by off-peak electricity in box (44) (the remainder being provided by full-rate electricity), taking professional advice as appropriate and allowing for the size of the storage tank.

			[ ]	(44)
Water heating (off-peak)	(43) ×	(44) =	[ ]	(45)
Water heating (full-rate)	(43) –	(45) =	[ ]	(46)

A.12 Fuel costs

Fuel prices are needed to calculate the energy cost. In addition to unit prices there are standing charges for gas and electricity, maintenance costs for fossil-fuel heating appliances, and the cost of running a circulating pump with wet radiator systems. Obtain these prices and charges from the local fuel supplier(s). Use Table 4 to convert to £/GJ.

Table 4 — Fuel conversion factors

Fuel	Price	Unit of price	Conversion factor	Price
				£/GJ
Electricity (on-peak)	[ ]	p/kWh	× 2.78 =	[ ]
Electricity (off-peak)	[ ]	p/kWh	× 2.78 =	[ ]
Gas	[ ]	p/therm	× 0.096 =	[ ]
Solid fuel	[ ]	£/therm	× 0.033 =	[ ]
Oil, paraffin	[ ]	p/L	× 0.27 =	[ ]
LPG (propane)	[ ]	p/L	× 0.39 =	[ ]
LPG (butane)	[ ]	p/L	× 0.20 =	[ ]

Item	Fuel used (in GJ)		Cost (in £/GJ)		Total cost (in £/annum)	
Space heating	(35) or (37)	×	______	=	[ ]	(47)
(on-peak part)	(38)	×	______	=	[ ]	(48)
Water heating	(43) or (45)	×	______	=	[ ]	(49)
(on-peak part)	(46)	×	______	=	[ ]	(50)
Lights and appliances	(39)	×	______	=	[ ]	(51)
Cooking	(40)	×	______	=	[ ]	(52)
Standing charges					[ ]	(53)
Maintenance charges (only if fuel used for heating)					[ ]	(54)
and pump running costs (if applicable)					[ ]	(55)
Total energy cost = (47) + (48) + . . . + (54) + (55)				=	[ ]	(56)

Appendix B Bibliography

NOTE This bibliography is not intended to be exhaustive but indicates some of the more important sources of information.

B.1 British Standards Institution publication

DD 93, *Methods for assessing exposure to wind-driven rain.*

B.2 Building Research Establishment Digests[4)]

Digest 170	Ventilation of internal bathrooms and WCs in dwellings
Digest 180	Condensation in roofs
Digest 206	Ventilation requirements
Digest 236	Cavity insulation
Digest 257	Installation of wall ties in existing construction
Digest 268	Common defects in low-rise traditional housing
Digest 270	Condensation in insulated domestic roofs
Digest 294	Fire risk from combustible cavity insulation
Digest 297	Surface condensation and mould growth in traditionally built dwellings
Digest 306	Domestic draughtproofing: ventilation considerations
Digest 319	Domestic draughtproofing materials, cost and benefits

B.3 Building Research Establishment Defect Action Sheets[4)]

The series of BRE Defect Action Sheets give information for designers and builders for the avoidance of defects in construction. Many of these are relevant to refurbishment work.

[4)] BRE Digests and Defect Action Sheets are available from Building Research Establishment, Garston, Watford, Herts WD2 7JR.

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Publications referred to

Standards publications

BS 3533, *Glossary of thermal insulation terms.*

BS 5250, *Code of basic data for the design of buildings: the control of condensation in dwellings.*

BS 5422, *Specification for the use of thermal insulating materials.*

BS 5617, *Specification for urea-formaldehyde (UF) foam systems suitable for thermal insulation of cavity walls with masonry or concrete inner and outer leaves.*

BS 5618, *Code of practice for thermal insulation of cavity walls (with masonry or concrete inner and outer leaves) by filling with urea-formaldehyde (UF) foam systems.*

BS 5720, *Code of practice for mechanical ventilation and air conditioning in buildings.*

BS 5803, *Thermal insulation for use in pitched roof spaces in dwellings.*

BS 5803-1, *Specification for man-made mineral fibre thermal insulation mats.*

BS 5803-2, *Specification for man-made mineral fibre thermal insulation in pelleted or granular form for application by blowing.*

BS 5803-3, *Specification for cellulose fibre thermal insulation for application by blowing.*

BS 5803-4, *Methods for determining flammability and resistance to smouldering.*

BS 5803-5, *Specification for installation of man-made mineral fibre and cellulose fibre insulation.*

BS 5925, *Code of practice for design of buildings: ventilation principles and designing for natural ventilation*[5].

BS 6232, *Thermal insulation of cavity walls by filling with blown man-made mineral fibre.*

BS 6232-1, *Specification for the performance of installation systems.*

BS 6232-2, *Code of practice for installation of blown man-made mineral fibre in cavity walls with masonry and/or concrete leaves.*

BS 6676, *Thermal insulation of cavity walls using man-made mineral fibre batts (slabs).*

BS 6676-1, *Specification for man-made mineral fibre batts (slabs).*

BS 6676-2, *Code of practice for installation of batts (slabs) filling the cavity.*

BS 8207, *Code of practice for energy efficiency in buildings.*

BS 8208, *Guide to assessment of suitability of external cavity walls for filling with thermal insulants.*

BS 8208-1, *Existing traditional cavity construction.*

BS 8208-2, *Existing cavity construction with walls exceeding 12 m in height*[6].

DD 93, *Methods for assessing exposure to wind-driven rain.*

Other publications

BREDEM *The BRE Domestic Energy Model. Background, philosophy and description.* BRE Report BR 66, 1985. Anderson B.R., Baldwin R., Clark A.J., Milbank N.O[a].

[a] This publication is available from the Building Research Establishment, Building Research Station, Garston, Watford, Herts WD2 7JR.

CIBSE Guide Section A3 1980, *The thermal properties of building structures*[7].

Good Practice Notes. Practice Note 1. *Cavity insulated walls*. Published jointly by Aggregate Concrete Block Association, 60 Charles Street, Leicester LE1 1FB. Brick Development Association, Woodside House, Winkfield, Windsor, Berkshire SL4 2DX. Cement and Concrete Association, Wexham Springs, Slough SL3 6PL. Eurisol-UK, 39 High Street, Redbourn, Herts AL3 7 LW. National Cavity Insulation Association, PO Box 12, Haslemere, Surrey GU27 3AN. British Plastics Federation, 5 Belgrave Square, London SW1X 8PH and is available from any of the publishers by quoting reference CIW-1.

[5] Referred to in the foreword only.
[6] In preparation.
[7] This publication is available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

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